

wounded. A perfect technological imitation may not be possible, but Oh and colleagues' work is a milestone in the search for electronic skins that behave much like their archetype. In the shorter term, healable soft electronic devices hold promise for truly bionic and smart electrical appliances, and might revolutionize future generations of wearables. ■

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MICROBIOLOGY

Deep-sea secrets of butane metabolism

Anaerobic microbes have been found to break down the hydrocarbon butane by a pathway with some similarities to anaerobic methane breakdown. Harnessing the butane pathway might enable biofuel generation. SEE ARTICLE P.396

STEPHEN W. RAGSDALE

Microbes living in anaerobic conditions, such as in deep-sea sediments, need a way of generating energy that does not require oxygen gas. Some anaerobic microbes do this by breaking down methane to form carbon dioxide¹. Others² obtain energy by metabolizing the hydrocarbon butane (C₄H₁₀), but the butane-breakdown pathway has until now been unknown. Determining how butane is metabolized might be useful for making biofuels or for developing efficient catalysts for hydrocarbon activation (the process of breaking a hydrocarbon's chemical bonds). On page 396, Laso-Pérez *et al.*³ report the pathway for microbial anaerobic breakdown of butane to CO₂. The authors identify some butane-breakdown steps ripe for further investigation, and observe that some similar steps have evolved in the microbial processes for degrading methane and butane.

Laso-Pérez and colleagues obtained deep-sea sediment samples from the Gulf of California and isolated fractions that could degrade butane. The butane degradation they observed depended on a microbial consortium formed of *Candidatus Syntrophoarchaeum* archaea and HotSeep-1 bacteria, two types of prokaryote (organisms lacking a nucleus). The authors found that the microbial consortium can also metabolize propane (C₃H₈), although it is not known whether propane and butane are

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4. Gsänger, M., Bialas, D., Huang, L., Stolte, M. & Würthner, F. *Adv. Mater.* **28**, 3615–3645 (2016).
5. Glowacki, E. D. *et al.* *Adv. Mater.* **25**, 1563–1569 (2013).
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7. Rogers, J. A., Someya, T. & Huang, Y. *Science* **327**, 1603–1607 (2010).
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9. Tong, K., Liang, J. & Pei, Q. *ECS Trans.* **75**, 205–212 (2016).
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degraded by the same enzymes or by different enzymes that have specific substrate preferences. However, the consortium does not degrade methane, nor several other short-chain hydrocarbons the authors tested.

Butane consists of carbon and hydrogen atoms linked by strong single bonds, and the molecule lacks a reactive group. The stability of the carbon–hydrogen (C–H) bond poses a formidable and interesting chemical challenge in butane breakdown. For anaerobic microbial breakdown of methane, the thermodynamically unfavourable hydrocarbon breakdown proceeds by coupling it to a thermodynamically favourable reaction: for example, the transfer of electrons to sulfate to form hydrogen sulfide (H₂S, a reduced form of sulfate)^{4,5}. Laso-Pérez and colleagues investigated whether such thermodynamic coupling might occur in their microbial consortium, and found evidence for sulfate reduction that depended on butane breakdown. In anaerobic methane degradation, sulfate reduction occurs by direct interspecies electron transfer^{3,4} from the archaea to their bacterial partner HotSeep-1. Laso-Pérez and colleagues find no evidence for sulfate-reduction genes in the archaea they studied, and propose that an interspecies electron-transfer mechanism also occurs in the butane-degradation pathway.

The authors determined experimentally that the overall butane-breakdown reaction consists of the conversion of butane, sulfate



50 Years Ago

Several oncogenic viruses have been known and studied for some years and it is therefore important to search for viruses as aetiological agents in human cancer ... A man 36 years old and of previous good health was referred to one of us ... with clinical evidence of hepatic malignancy. The presence of primary hepatoma had been confirmed at laparotomy. A liver biopsy specimen was obtained by means of a needle ... Histological examination showed the presence of poorly differentiated hepatocarcinoma ... In addition, particles were found in the cytoplasm of some 90 per cent of the eighty tumour cells examined ... Their size and shape indicate that these particles are viral in nature. It has recently been suggested, however, that particles seen as viruses under the electron microscope in various human leukaemia states may have been mycoplasma, small free living micro-organisms with many virus-like properties. The true nature of the particles we have seen must therefore await identification.

From *Nature* 19 November 1966

100 Years Ago

Judging from the correspondence which has recently appeared in *NATURE*, the dearth of wasps this autumn in many parts of England has been most pronounced ... I was staying, with my wife and son, in a cottage on Christon Hill, on the Mendip Hills ... we were simply besieged by wasps, which were particularly tiresome at the breakfast-table. They were so numerous at times ... that we frequently had to abandon our meals temporarily to punish the offenders, my son continuing his captures often for half an hour at a time ... I cannot recollect ever having seen so many wasps in a house, unless it was during the hottest part of 1911.

From *Nature* 16 November 1916